REMARKS

Claims 1, 10, 35, 38, 72, and 75-82 are amended and claims 34 and 71 are canceled hereby. Accordingly, after entry of this Amendment, claims 1-6, 8-20, 22, 24-26, 28-33, 35-41, 43-55, 57, 59-61, 63-70, and 72 -82 remain pending.

In the Office Action, the Examiner maintained the rejections of claims 1-6, 8-15, 17-20, 22, 24-26, 28-41, 43-50, 52-55, 57, 59-61, 63-74, and 75-82 under 35 U.S.C. § 103(a) as being unpatentable over Chung et al. (U.S. Patent Publication 2003/0203616) in view of Lai et al. (U.S. Patent 6,939,804). In addition, claims 16 and 51 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Chung et al. and Lai et al. in view of Elers et al. (U.S. Patent Publication 2003/0203616). The Applicant respectfully disagrees with each of these rejections and, therefore, respectfully traverses the same.

In response, the Applicant has amended claims 1, 10, 35, 38, 72, and 75-82. In particular, independent claims 1 and 38 have been amended to put an upper limit of "about 60 angstrom (A)" for the thickness of the metal layer (claim 1) and W layer (claim 38) deposited in each deposition cycle. The Applicant respectfully submits that all of pending claims are patentable over the references cited by the Examiner because they recite a method of depositing a metal layer on a substrate (claim 1) or a method of depositing a W layer on a substrate (claim 38) that combines a number of features including, among them, performing a plurality of deposition cycles to deposit a metal layer (claim 1) or a W layer (claim 38) with a desired total thickness, each deposition cycle comprising: first, exposing the substrate to a metal-carbonyl precursor gas (claim 1) or a $W(CO)_6$ precursor gas (claim 38) to deposit a thickness between greater than 5 angstrom (A) and about 60 angstrom (A) of the metal layer (claim 1) or the W layer (claim 38) on the substrate, wherein the substrate is maintained at a substrate temperature that results in thermal decomposition of the metal-carbonyl precursor gas (claim 1) or the $W(CO)_6$ precursor gas (claim 38), and second, exposing the metal layer (claim 1) or the W layer (claim 38) to a reducing gas.

In the Response to Arguments section of the Office Action, the Examiner states that Chung et al. in view of Lai et al. disclose that when the carbonyl precursor is thermally decomposed as taught by Chung et al., layer thicknesses of up to 300-1500 angstroms result for the metal layer. In addition, the examiner indicates that Lai et al. teaches that during a cyclical deposition process, the deposition rate of the metal layer varies as a function of the metal precursor (column 10 lines 9-25), showing that it would be obvious to modify this variable by routine examination.

The Applicant respectfully points out that Lai et al. teaches in column 9, lines 55-65 depositing a metal layer with a thickness of up to 300-1500 angstroms in a single continuous deposition step, not in a plurality of deposition cycles as required by Claims 1 and 38. Some of the advantages of performing a plurality of deposition cycles are described in paragraphs [0031] – [0032] of the present invention. In particular, thermal decomposition of metal-carbonyl precursors and subsequent metal deposition on a substrate can lead to incorporation of CO by-products into the metal layers, thereby increasing the (electrical) resistivity of the metal layer and can lead to poor surface morphology due to abnormal growth of nodules (metal particles) on the surface of metal layer and/or in the metal layer. The current inventors realized that a thin metal layer that is between about 5 A and about 60 A thick may be deposited on a substrate by exposing the substrate to a metal-carbonyl precursor gas comprising a metal-carbonyl precursor and optionally a carrier gas and a dilution gas, and thereafter, the deposited metal layer may be exposed to a reducing gas, and optionally a dilution gas, to aid in the removal of CO by-products and impurities from the deposited metal layer. Following the exposure of a reducing gas to the metal layer, the deposition of the metal layer can be repeated to deposit a thicker metal layer.

Since Chung et al. teaches depositing a metal layer with a thickness of up to 300-1500 angstroms in a single continuous deposition step, the above-described advantages of performing a plurality of deposition cycles to deposit a thickness between greater than 5 angstrom (A) and about 60 angstrom (A) of the metal layer in each deposition cycle, cannot be achieved by the teachings of Chung et al. Furthermore, Lai et al. describes in column 10, lines 9-25, deposition rates between 10A/min and 30A/min for a continuous CVD process, and in column 10, lines 14-25, deposition rates between 0.3A/cycle and 1.1A/cycle for a cyclical ALD process. Therefore, the teachings of Lai et al. only allow deposition of up to 1.1A/cycle in a cyclical ALD process, not between greater than 5 angstrom and about 60 angstrom in each deposition cycle, as required by Claims 1 and 38.

Regarding claim 1, the Examiners refers to paragraphs [0030] – [0034] and [0046] in Chung et al. to conclude that a method is disclosed of depositing a metal layer on a substrate by providing a substrate to a process chamber and performing a deposition cycle until the thickness of the metal layer is greater than 5 A by exposing the substrate to a metal-carbonyl and reducing gas. A careful review of these paragraphs in Chung et al. shows that a plurality of deposition cycles are performed to achieve a thickness greater than 5 A. In particular, 30 deposition cycles are performed to deposit a thickness of about 30 A. Therefore, a thickness

of about 1 A is deposited in each deposition cycle, not a thickness between greater than 5 angstrom and about 60 angstrom in each deposition cycle as required by claim 1.

The Examiner refers to Column 2, lines 1-20 to conclude that Lai et al. uses a similar process as Chung et al. but also teaches that a precursor may be thermally decomposed in a CVD process, and that this would imply that the substrate is at a temperature to achieve this. The Examiner further refers to Figure 8A of Lai et al. which shows that the film thickness is a function of precursor exposure time, and the Examiner states that precursor exposure in Lai et al. (Column 6, lines 37-55) is modified depending upon the equipment used and thickness desired. The Applicant respectfully points out that FIG. 8A shows deposition rates for a tungsten nucleation layer formed using a cyclical deposition process, where the deposition rate saturates at about 1.1A/cycle (110A/100cycles) at high enough exposure times. Therefore, FIG. 8 in Lai et al. cannot teach or suggest depositing a thickness between greater than 5 angstrom and about 60 angstrom in each deposition cycle as required by claim 1.

The Examiner further refers to Lai et al. (Column 9, lines 55-65) to describe a CVD process where a film thickness of 300-1500 angstroms is achieved. The Applicant respectfully points out that a CVD process (a non-cyclical deposition process) is described to deposit bulk tungsten, not a plurality of deposition cycles with a thickness between greater than 5 angstrom and about 60 angstrom of a metal layer deposited in each deposition cycle as required by claim 1.

The Examiner further concludes that one of ordinary skill in the art would want to use the CVD thermal decomposition to deposit the tungsten carbonyl compound in Chung et al. as taught by Lai et al. because more than a monolayer can be deposited and the amount of gas pulses needed and complexity of the process would lessen, and that this is suggested by both references. The Applicant respectfully points out that this conclusion is flawed because, in Chung et al., a tungsten carbonyl compound is adsorbed on the substrate in each deposition cycle by exposing a substrate to a tungsten carbonyl precursor and then borane (a reducing gas) is exposed to the substrate to facilitate conversion to the tungsten carbonyl compound to tungsten. However, claim 1 requires that a metal layer (a W metal layer in claim 38) be deposited with a thickness between greater than 5 angstrom and about 60 angstrom in each deposition cycle, not a tungsten carbonyl compound. As explained earlier, Lai et al. describes a CVD process to deposit bulk W metal.

Furthermore, the Examiner concludes that one of ordinary skill in the art would recognize that depositing the material by thermal decomposition would give a first layer of

greater adherence to the substrate, which would be beneficial to both Chung et al. and Lai et al., and in addition, that one of ordinary skill in the art would be motivated to pulse a reducing gas even after the tungsten is deposited by CVD as taught by Chung et al. because pulsing the reducing gas allows for complete conversion to tungsten metal from tungsten carbonyl and ensures the desired film properties (paragraph [0033] of Chung et al.) The Examiner further states that both references state that cyclic deposition processes are beneficial to deposit layers of desired thickness in a controllable manner. Again, the Applicant respectfully points out that Chung et al. does not describe or teach the use of plurality of deposition cycles to deposit a metal layer with a thickness between greater than 5 angstrom and about 60 angstrom in each deposition cycle. Lai et al. does not cure that deficiency by describing a deposition of bulk W metal using a non-cyclical CVD process.

Ehlers et al. does not assist the Examiner with a rejection of the claims because it also fails to describe or suggest any of the features that are absent from Chung et al. and Lai et al.

In summary, the Applicant respectfully submits that claims 1-6, 8-20, 22, 24-26, 28-33, 35-41, 43-55, 57, 59-61, 63-70, and 72 -82 are not rendered obvious by any of the references relied upon by the Examiner. In view of the foregoing, therefore, the Applicant respectfully requests reconsideration and allowance of the present application.

Applicant is of the opinion that a one-month extension of time is due with this amendment. If there are any other fees required for this submission that are not otherwise accounted for, please charge any fees such associated with the submission of this paper to Deposit Account Number 503451. The Commissioner for Patents is also authorized to credit any over payments to the above-references Deposit Account.

Respectfully submitted,
TOKYO ELECTRON U.S. HOLDINGS, INC.

By /Audunn Ludviksson/

Audunn Ludviksson, Reg. No.: 57,249

4350 W. Chandler Blvd, Suite 10
Chandler, AZ 85226
Tel.No.: 480-539-2106
Fax No.: 480-539-2100